

# ALUMINUM

## Project Fact Sheet



### SPRAY ROLLING ALUMINUM STRIP

#### BENEFITS

- Increase in the metal's surface area by a factor of  $10^{10}$ , thereby permitting substantial heat extraction rates in the spray with convection heat transfer coefficients in excess of  $10^4 \text{ Wm}^{-2}\text{K}^{-1}$
- Increase in cooling rate of one to three orders of magnitude compared to twin-roll casting
- Savings of  $4.6 \times 10^{12} \text{ kJ/year}$  for the U.S. aluminum industry by eliminating intermediate, energy-intensive, conventional ingot casting/hot rolling processes

#### APPLICATIONS

This project seeks to contribute to the U.S. aluminum industry by demonstrating and developing a unique approach to strip and sheet production. Realization of the proposed technique will expand the industry's understanding on net-shape manufacturing utilizing spray forming, and allow the production of net-shape materials with more complex geometries.

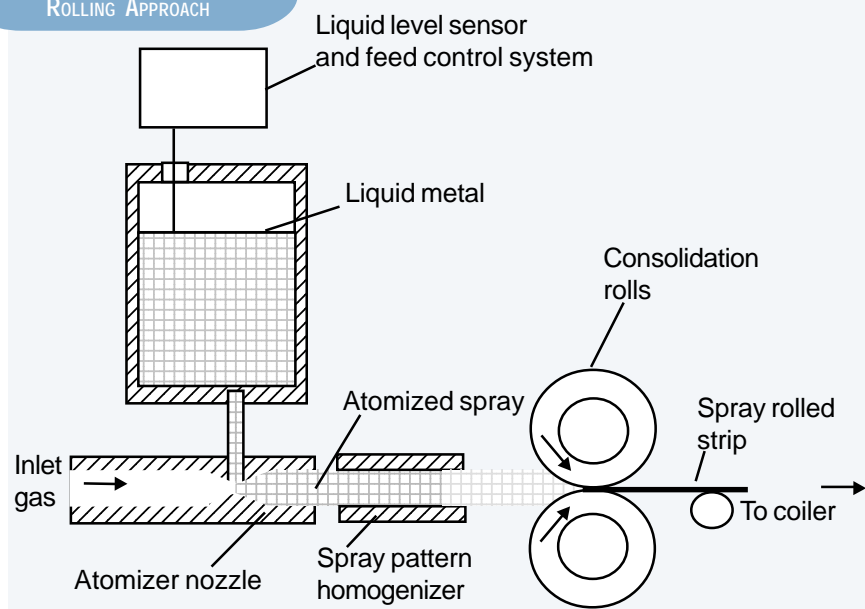
### NEW PROCESS COMBINES BENEFITS OF TWIN-ROLL CASTING AND SPRAY FORMING

Nearly all aluminum strip is manufactured commercially by conventional ingot metallurgical (I/M) processing, also known as continuous casting. This method accounts for about 70% of domestic production. However, it is energy and capital equipment intensive.

Spray forming is a competitive low-cost alternative to ingot metallurgy for manufacturing ferrous and non-ferrous alloy shapes. It produces materials with a reduced number of processing steps, while maintaining materials properties, with the possibility of near-net-shape manufacturing. However, there are several hurdles to large-scale commercial adoption of spray forming: 1) ensuring strip is consistently flat, 2) eliminating porosity, particularly at the deposit/substrate interface, and 3) improving material yield.

Researchers are investigating a *spray rolling* approach to overcome these hurdles. It should represent a processing improvement over conventional spray forming for strip production. Spray rolling is an innovative manufacturing technique to produce aluminum net-shape products. It requires less energy and generates less scrap than conventional processes and, consequently, enables the development of materials with lower environmental impacts in both processing and final products. It combines benefits of twin-roll casting and conventional spray forming.

#### SCHEMATIC OF SPRAY ROLLING APPROACH



Schematic of the spray rolling approach for manufacturing ferrous and non-ferrous alloy shapes.



## Project Description

**Goals:** The goal of this project is to demonstrate the feasibility of the spray rolling process at the bench-scale level and evaluate material properties of spray-rolled aluminum strip alloys. Also, it will demonstrate 2X scalability of the process and document technical hurdles to further scale up and initiate technology transfer to industry for eventual commercialization of the process. Spray rolling combines spray forming, identified as a key need in the Aluminum Industry Technology Roadmap, with rolling for the net-shape manufacturing of aluminum strip.

## Progress and Milestones

### Year One:

- Modifications to be made on the existing spray forming facility will be identified. Gas-liquid reactive spray atomization experimental methods and numerical models will be developed. The primary tasks will include the definition of a relevant range of processing conditions for spray forming and the identification for suitable chemical reactions for reactive spray forming.

### Year Two:

- Processing parameters for a given alloy will be established for each processing set-up. Of particular significance are the droplet size distribution, velocity, solid fraction, temperature and flux at the point of impact with the rolls, and droplet wetting behavior after impact.
- Advanced multidimensional, fully-coupled, multiphase flow models integrating the entire nozzle and plume regions which include droplet recalescence will be modified for use with spray rolling aluminum alloys. This will guide and reduce the experimental matrix to help determine the detailed thermal and solidification histories which the droplets have seen "in-flight" and at impact, and provide guidance for component designs.

### Year Three:

- This phase will emphasize demonstration of 2X scalability of the process and technology transfer to industry.
- Industry personnel will be trained to use the equipment. Design drawings for the equipment will be transferred to industry participants for on-site duplication.
- Experiments will be conducted to assess the superplastic behavior of the spray formed, reactive spray deposited, and spray-rolled materials. The emphasis will be the relationship between microstructural factors, such as grain size and porosity, and the superplastic response.
- Numerical simulations will help establish working relationships between the spray conditions and microstructural features.



### PROJECT PARTNERS

Alcoa Incorporated  
Pittsburgh, PA

Century Aluminum of West Virginia  
Ravenswood, WV

Colorado School of Mines  
Golden, CO

Idaho National Engineering and  
Environmental Laboratory  
Idaho Falls, ID

Inductotherm Corporation  
Rancocas, NJ

Metals Technology, Incorporated  
Northridge, CA

University of California  
Irvine, CA

**FOR ADDITIONAL INFORMATION,  
PLEASE CONTACT:**

### PROJECT INFORMATION

Enrique J. Lavernia  
Department of Chemical and  
Biochemical Engineering and  
Materials Science  
University of California  
Irvine, CA 92697-2575  
Phone: (949) 824-8714

### ALUMINUM PROGRAM

Simon Friedrich  
Office of Industrial Technologies  
Phone: (202) 586-6759  
Fax: (202) 586-6507  
simon.friedrich@ee.doe.gov  
<http://www.oit.doe.gov/aluminum>

Please send any comments,  
questions, or suggestions to  
[webmaster.oit@ee.doe.gov](mailto:webmaster.oit@ee.doe.gov).

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Office of Industrial Technologies  
Energy Efficiency  
and Renewable Energy  
U.S. Department of Energy  
Washington, D.C. 20585



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